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Fujikawa et al.

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[45] **Date of Patent: Apr. 12, 1988**

[54] VALVE GEAR FOR FOUR-CYCLE ENGINE

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[73] Assignee: **Kawasaki Jukogyo Kabushiki Kaisha**, Japan

[21] Appl. No.: **848,206**

[22] Filed: **Apr. 4, 1986**

[30] **Foreign Application Priority Data**

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Feb. 17, 1986 [JP] Japan 61-32539

[51] **Int. Cl.**[4] **F01L 1/04**

[52] **U.S. Cl.** **123/90.2**; 123/90.6

[58] **Field of Search** 123/90.2, 90.21, 90.22, 123/90.23, 90.6

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Primary Examiner—Ira S. Lazarus

[57] **ABSTRACT**

A valve gear for a four-cycle engine having an overhung crankshaft connecting with an output shaft, wherein a guide portion having such a shape folding the output shaft as to return back to a starting point in two turns, is formed on the output shaft, and an interlocking mechanism guided by the guide portion is provided to open the valves for the four-cycle engine. It is preferable that the guide portion is formed as cam face displacing the interlocking mechanism. The guide portion can be formed on a block other than the output shaft for easy machining and also for adjustable valve timing.

1 Claim, 5 Drawing Sheets

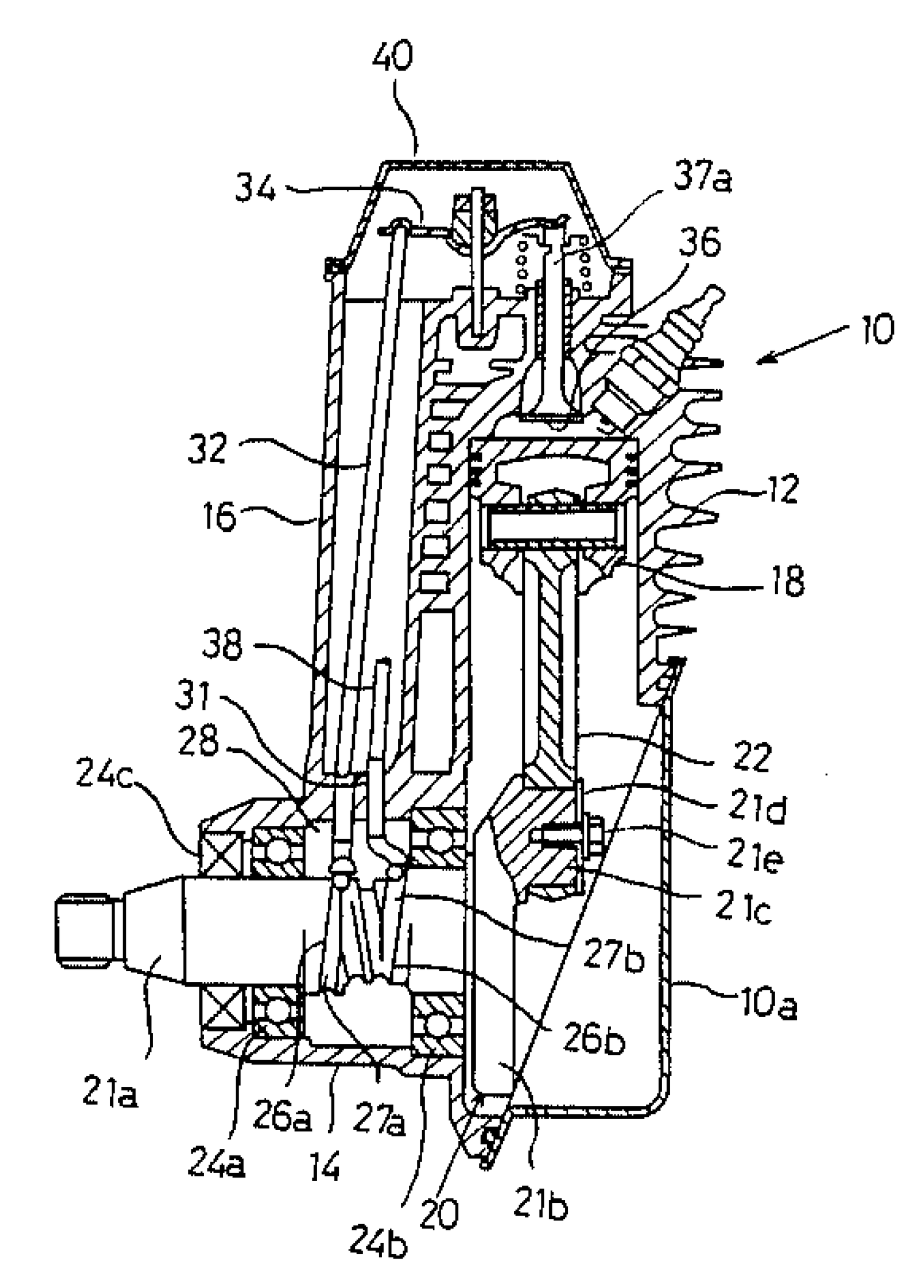
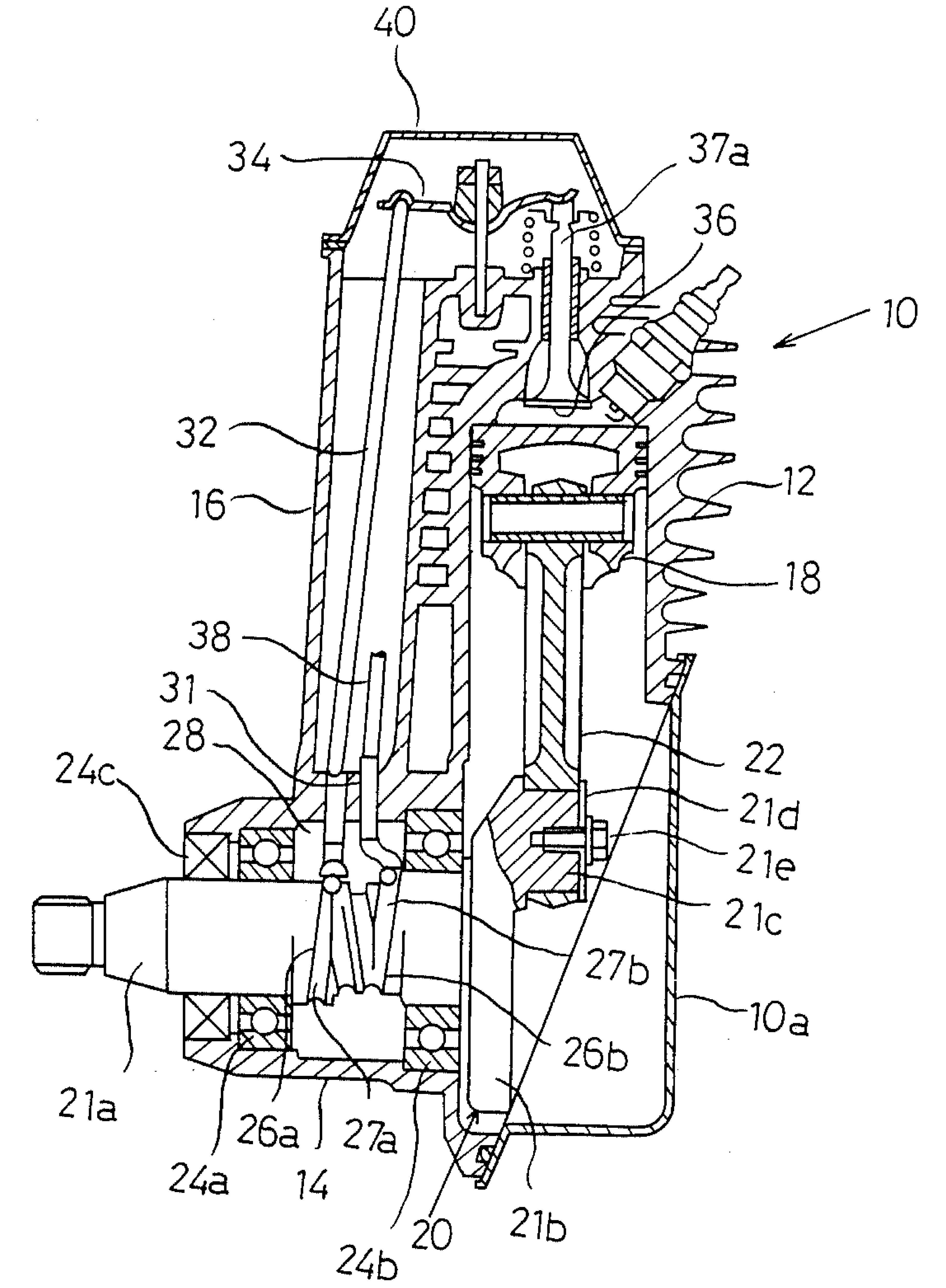


FIG. 1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34
37a
36
10
32
16
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38
31
28
24c
22
21d
21e
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26b
21a
26a
27a
24a
14
20
21b
24b

FIG. 3

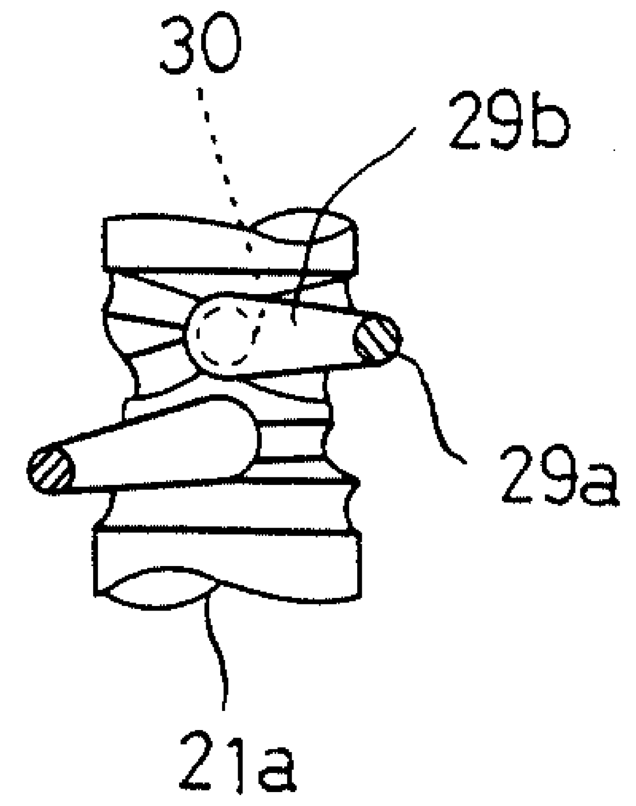


FIG. 2

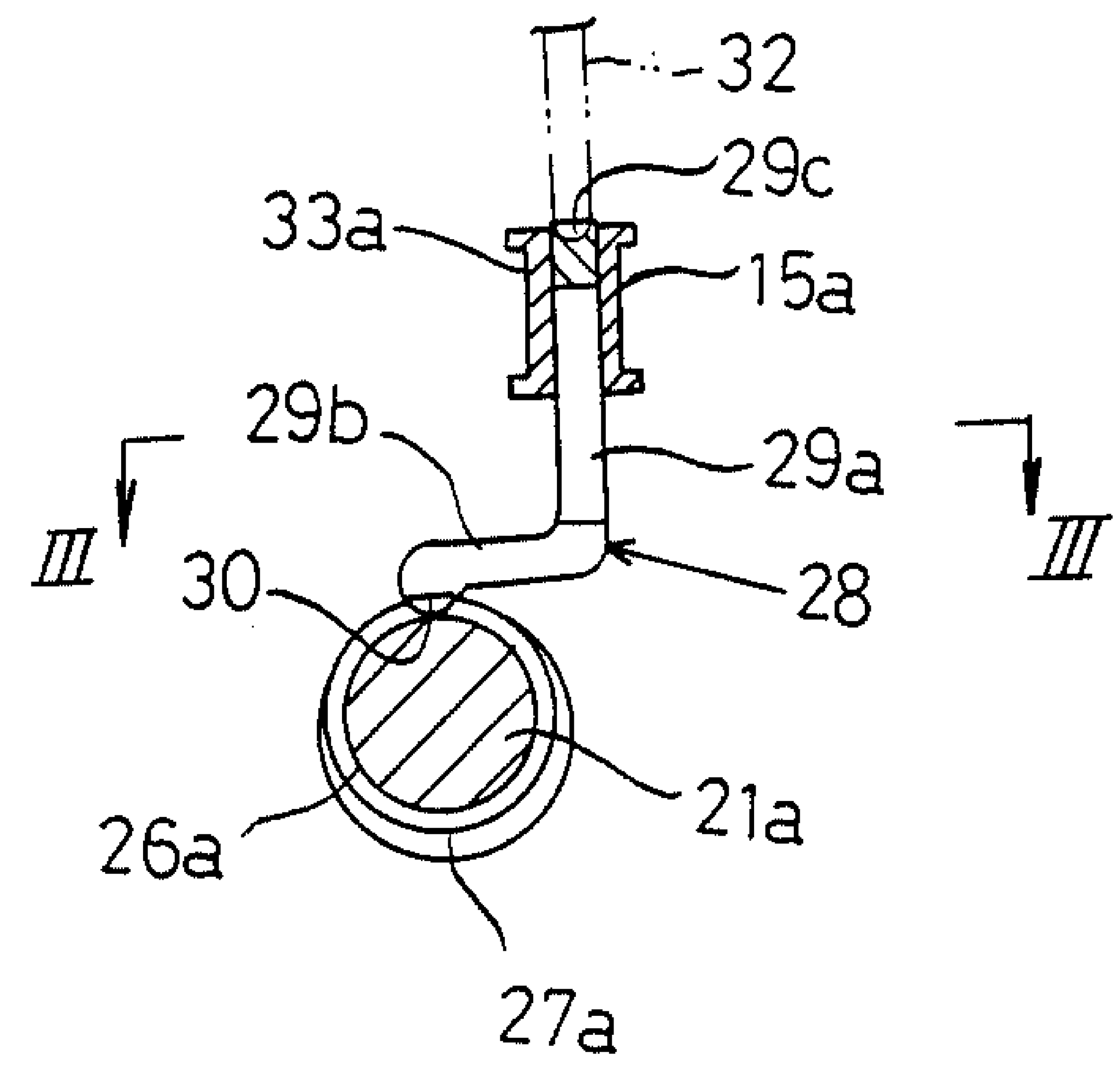


FIG. 4

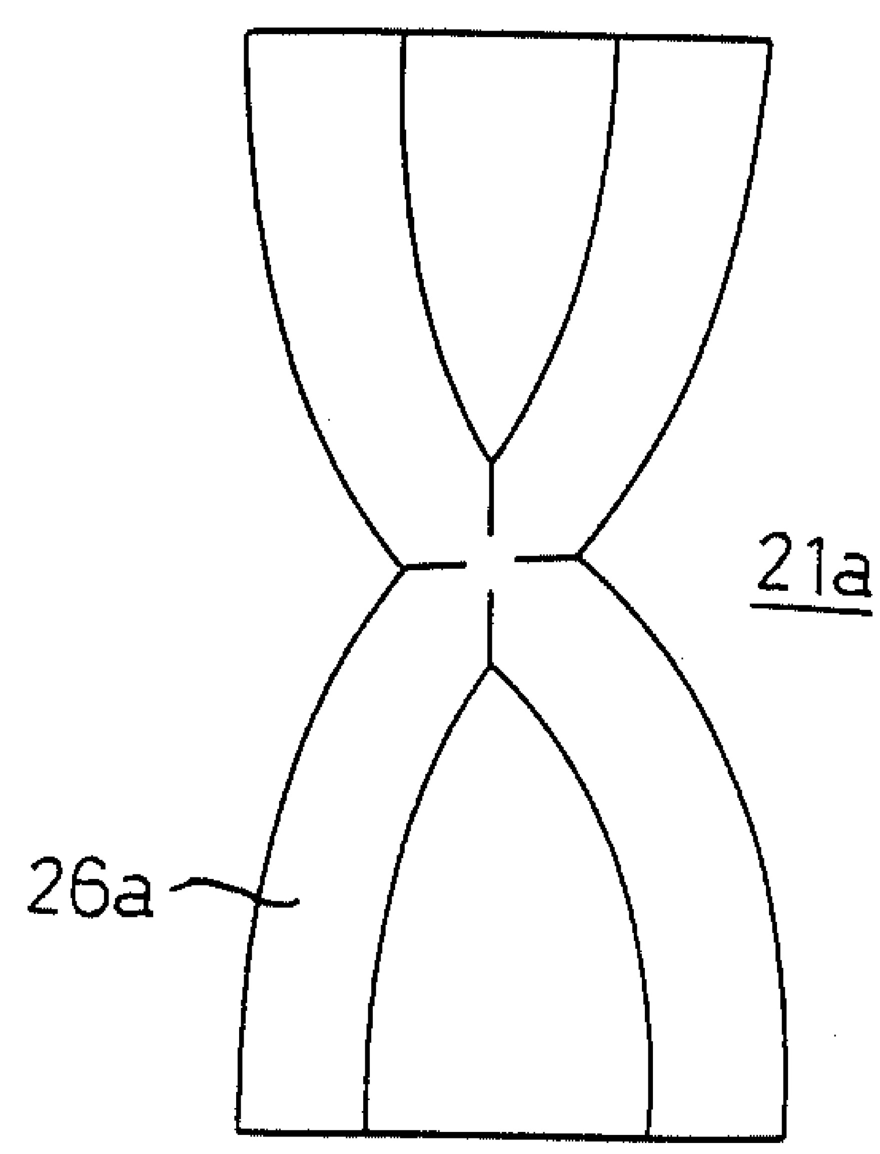


FIG. 5

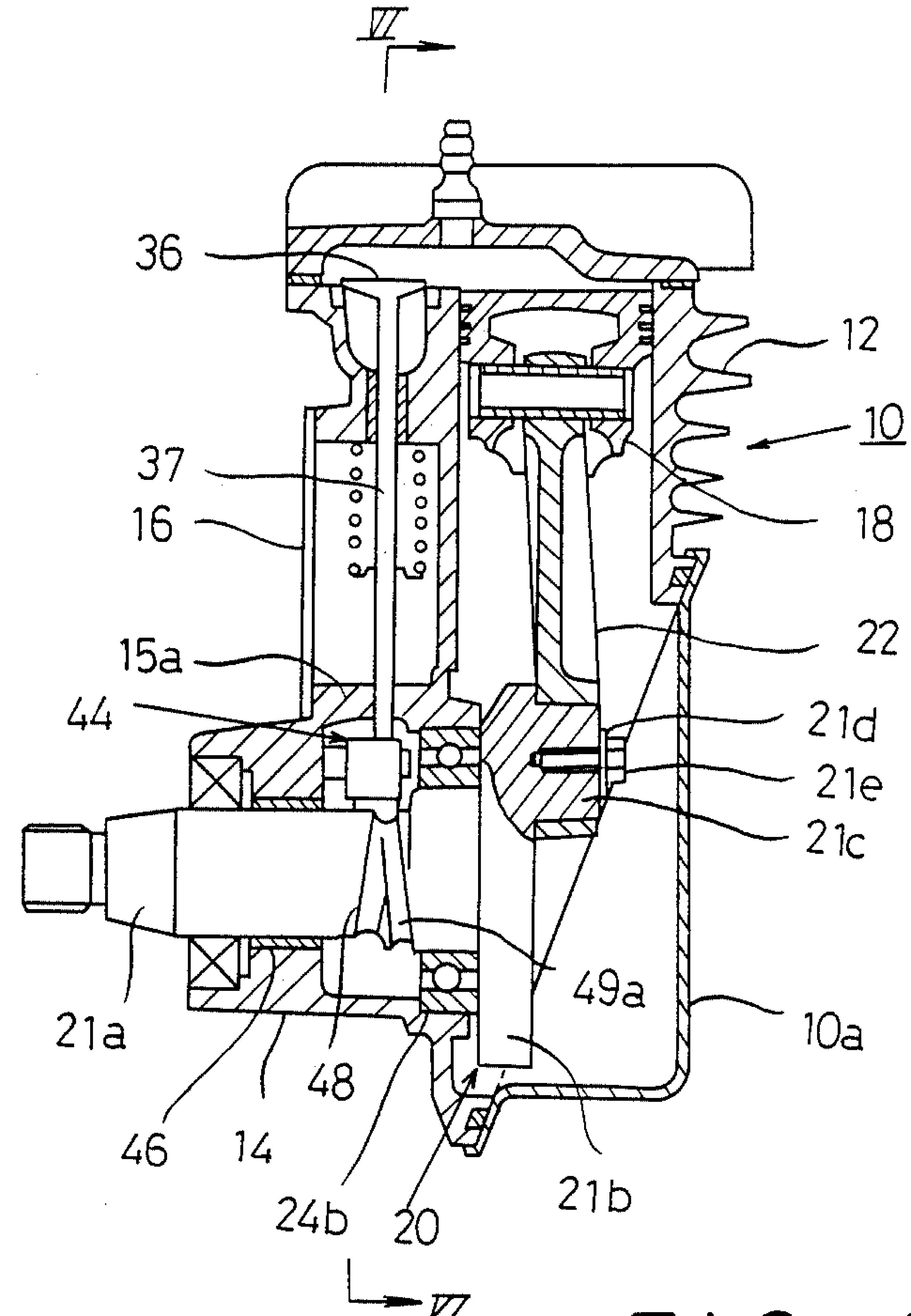
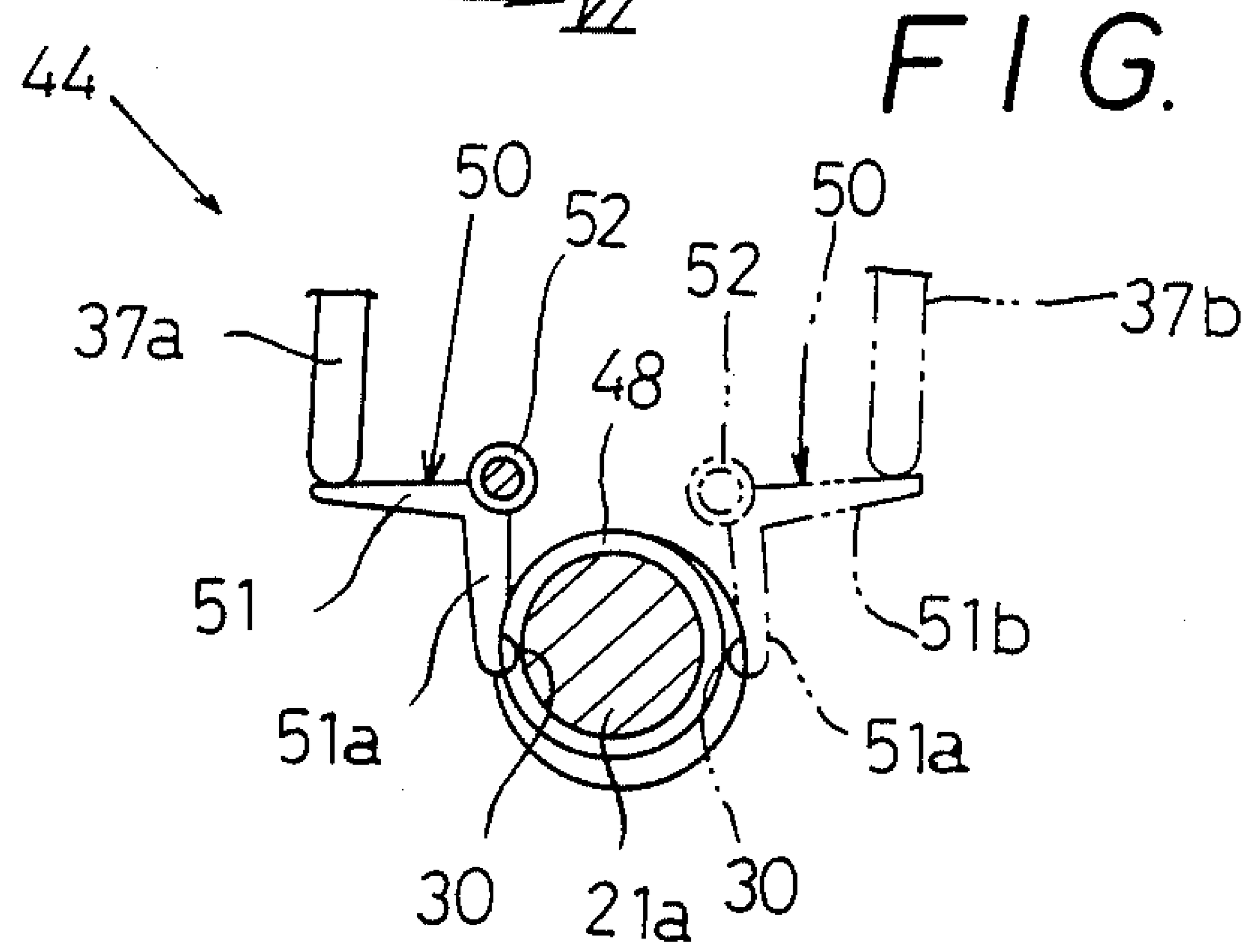

VI
36
12
10
37
16
18
22
15a
44
21d
21e
21c
49a
21a
10a
48
46
14
21b
24b
20
VI

FIG. 6


44
50
52
52
50
37a
37b
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51
51b
51a
51a
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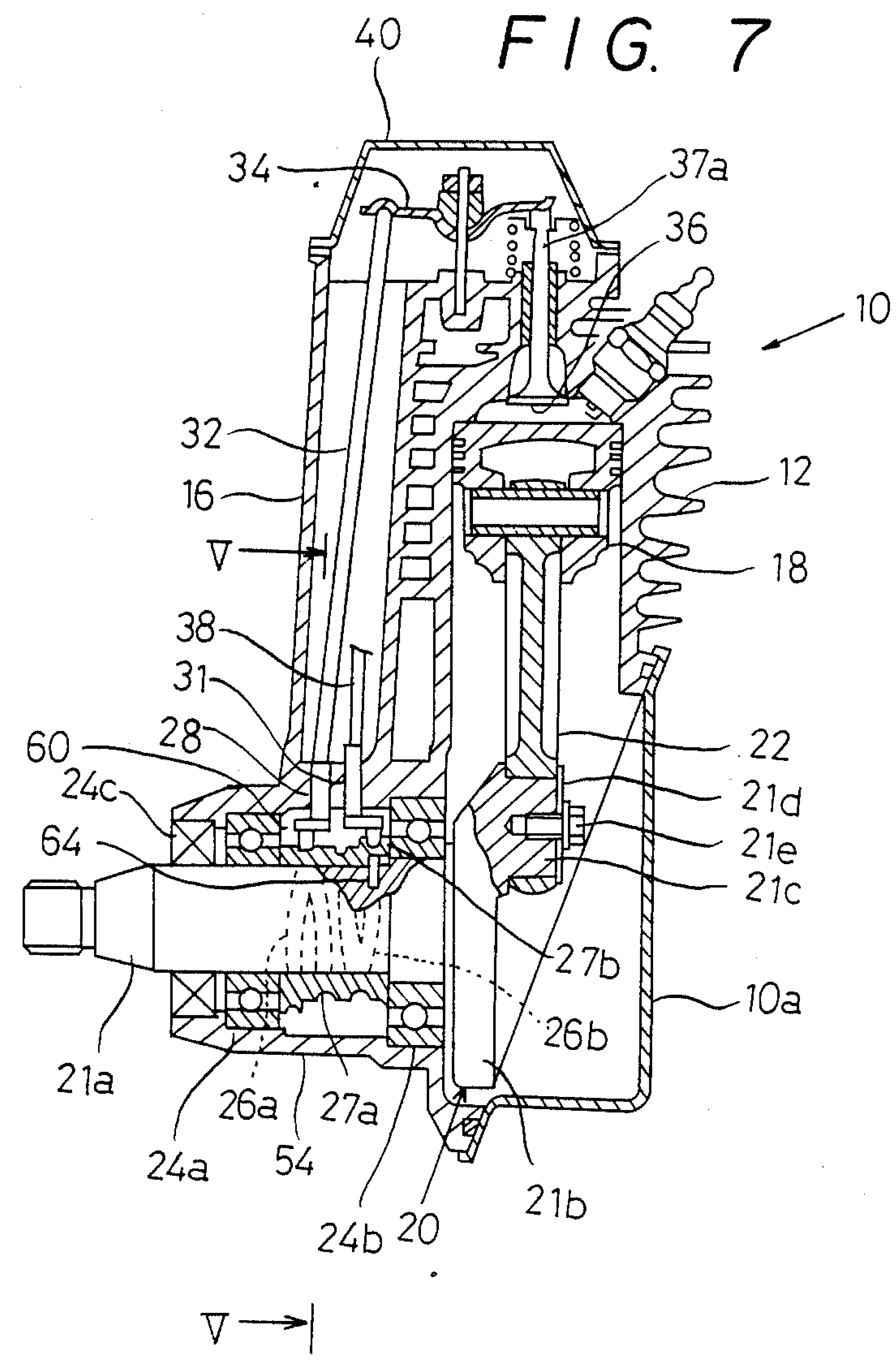
21a
30

FIG. 7


40
34
37a
36
10
32
16
12
18
V
38
31
28
60
24c
64
22
21d
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10a
26b
21a
26a
27a
24a
54
24b
20
21b
V

FIG. 8

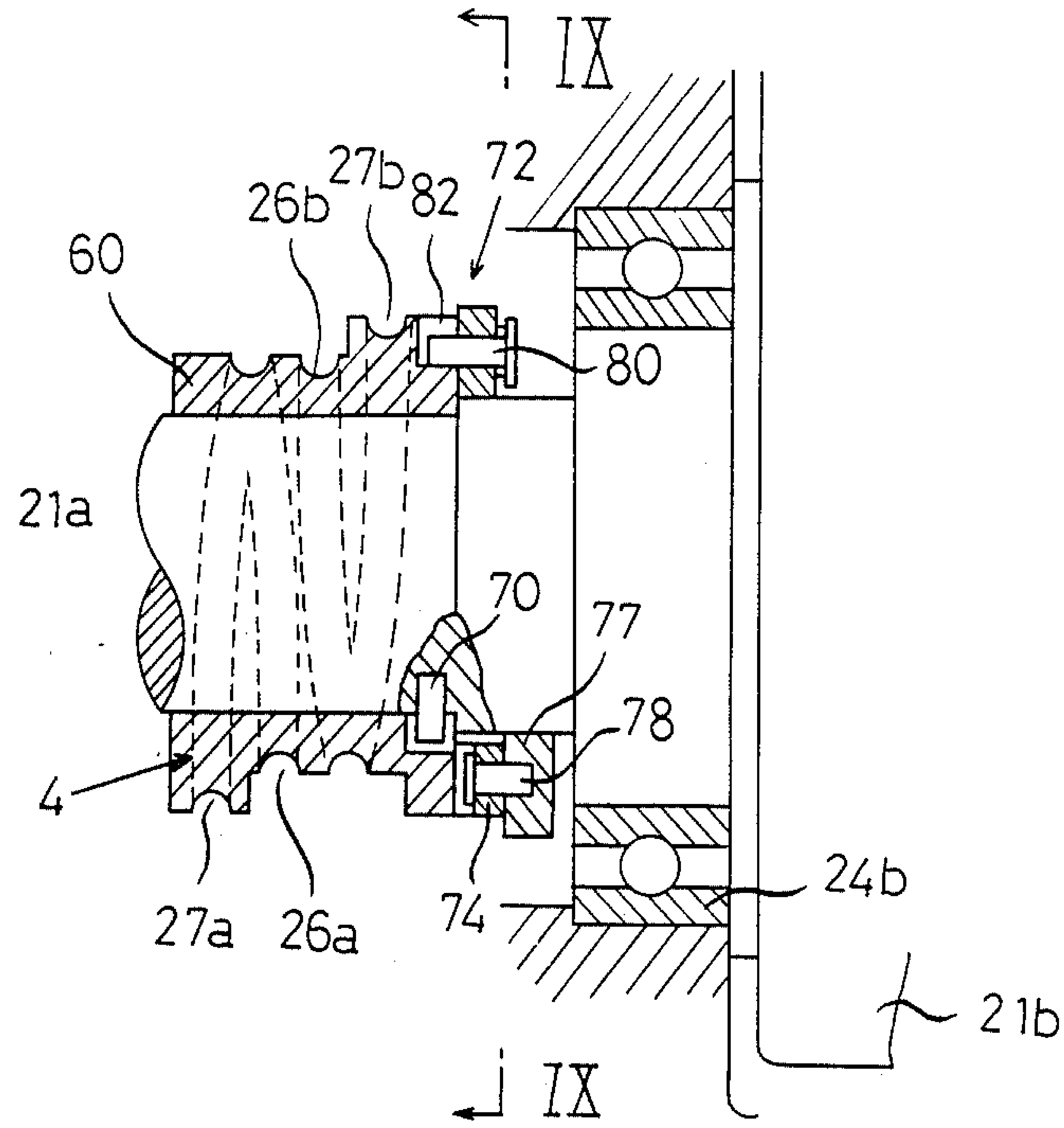


FIG. 9

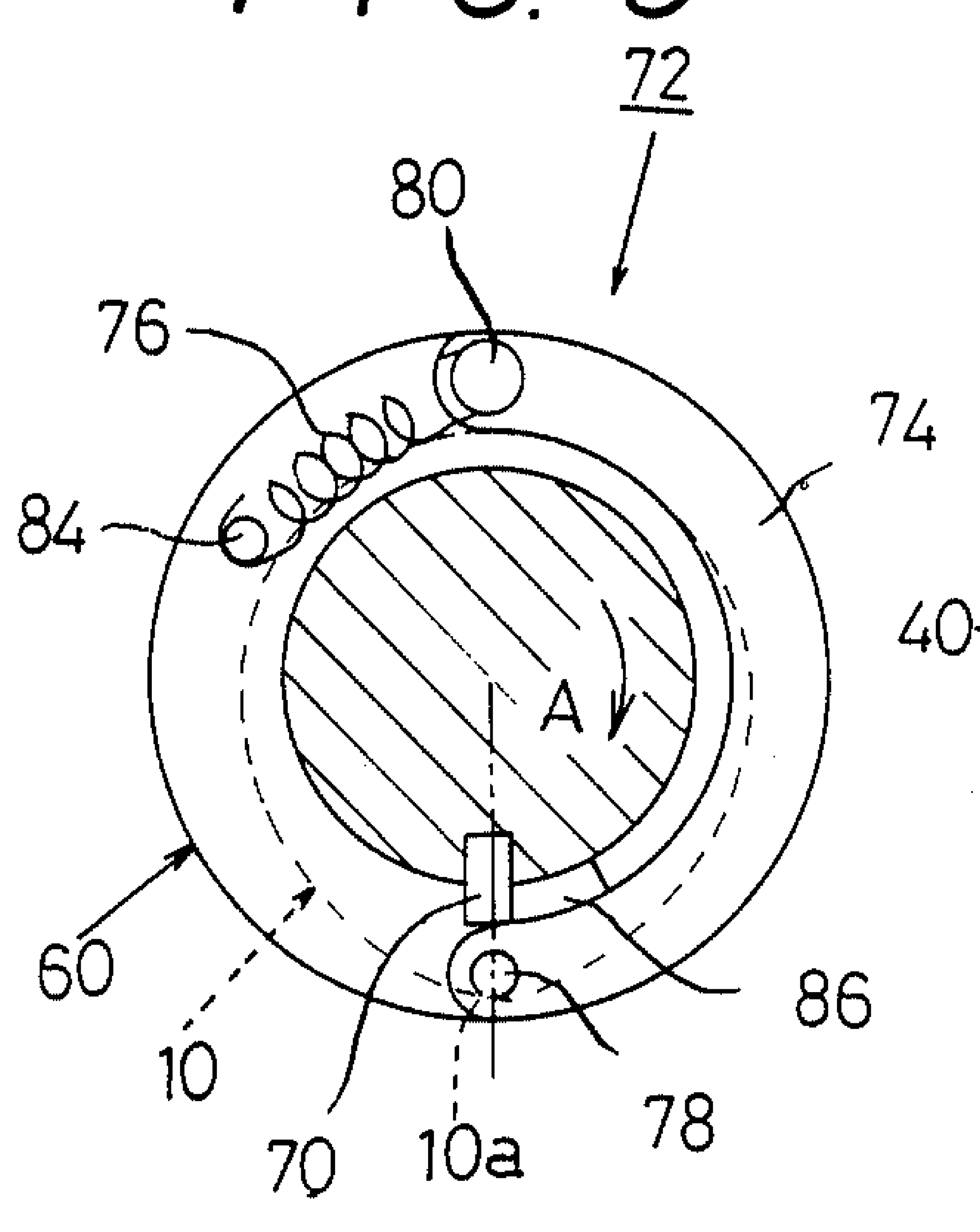
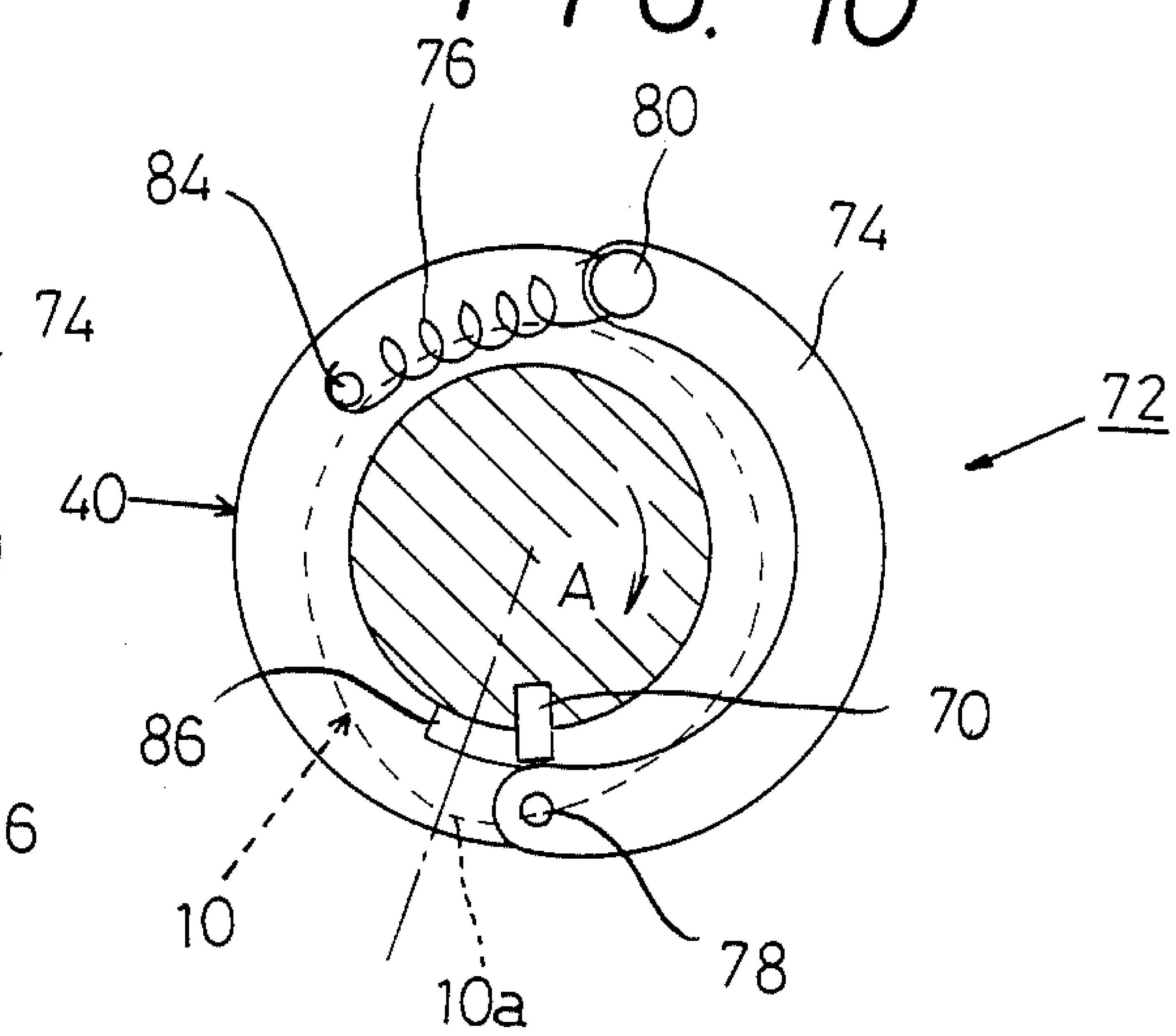


FIG. 10



VALVE GEAR FOR FOUR-CYCLE ENGINE

FIELD OF THE INVENTION AND RELATED ART STATEMENT

This invention relates to a valve gear adapted for the general-purpose four-cycle engine of small size and simple construction having an overhung crankshaft to which an output shaft is connected.

Generally, the small general-purpose four-cycle engine requires low cost, light weight and compactness.

To meet aforesaid requirements, the prior art with relation to the overhung crankshaft has been known, wherein the cam shaft for driving the valves is disposed at right angles to the crankshaft to transmit the power from the crankshaft to the cam shaft through screw gearing.

This construction, however, requires not only the cam shaft but also the bearings for the cam shaft, which makes the engine large in size owing to a space for containing both of them.

Furthermore, the configuration results in high cost caused by the cam shaft and screw gearing, reduced reliability due to the wear of the screw gearing, and more complicated construction.

OBJECT AND SUMMARY OF THE INVENTION

It can be said that the purpose and object of this invention is to provide a valve gear adapted for the four-cycle engine low in cost, light in weight, compact and simple in construction, and high in reliability, eliminating aforesaid problems associated with the conventional valve gear using the screw gearing.

To achieve aforesaid object, a valve gear according to the invention adapted for the four-cycle engine having the overhung crankshaft connected to the output shaft, comprises a guide portion formed around the output shaft into such a shape as to return back to the starting point in turns, and an interlocking mechanism guided by the guide portion to open and close the valve system of the four-cycle engine.

It is advisable that aforesaid guide portion be formed into a cam face which displaces the interlocking mechanism as to open and close the valves.

Forming aforesaid guide portion between bearings disposed at two separate locations on the output shaft, prevents the rotation axis of the guide portion from being fluctuating due to the combustion force in the engine acting on the crankshaft.

Furthermore, aforesaid small guide portion is preferably prefabricated from a block other than the output shaft for accurate machining.

And, if aforesaid guide portion is prefabricated separately from the crankshaft and assembled thereon rotatably, and also a timing control mechanism to adjust the circumferential angle position of the guide portion on the crankshaft is provided for variable timing control, the timing control mechanism enables the valve timing to be matched for engine performance.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawings, there are shown illustrative embodiments of the invention from which these and other of its objectives, novel features and advantages will be readily apparent.

In the drawings:

FIG. **1** is a vertical sectional view of a first embodiment for a four-cycle engine according to the invention.

FIG. **2** is a vertical sectional view of a sliding piece in FIG. **1**.

FIG. **3** is a sectional view taken along line III—III in FIG. **2**.

FIG. **4** is a segmentary side view of the guide portion.

FIG. **5** is a vertical sectional view of another embodiment for the four-cycle engine according to the invention.

FIG. **6** is a partly sectional fragmentary illustration taken along line VI—VI in FIG. **5**.

FIG. **7** is a vertical sectional view of a third embodiment for the engine.

FIG. **8** is a vertical sectional view of the major parts of an engine according to a fourth embodiment.

FIG. **9** is a sectional view taken along line IX—IX in FIG. **8**.

FIG. **10** is a schematic illustration showing the construction of the centrifugal governor operating at high speed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a small and versatile overhead valve type four-cycle engine according to the invention. In FIG. **1**, Numeral **10** designates an engine block. A cylinder **12**, a crankcase **14** and side cover **16** etc. are integrated into the engine block **10**. The engine block **10** is opened cut obliquely at the right lower end portion thereof in the figure and enclosed by means of an oil pan ***10a***.

A piston **18** slidably fits into the cylinder **12**, and a overhung crankshaft **20** is rotatably supported by the crankcase **14**. And the piston **18** is connected to the overhung crankshaft **20** through a connecting rod **22**.

The overhung crankshaft **20** is a one-piece forging consisting of an output shaft ***21a***, a crank web ***21b*** and a crankpin ***21c***. A side plate ***21d*** is mounted on the crankpin ***21c*** by means of a bolt ***21e***. The output shaft ***21a*** is supported to the crankcase **14** by two bearings ***24a*** and ***24b*** spaced by a fixed gap. The reason why the bearing ***24b*** is larger in diameter than the other bearing ***24a*** is to bear the combustion force acting on the overhung crankshaft **20**, to readily load the bearings ***24a*** and ***24b***, and to easily force-fit the output shaft ***21a***. Numeral ***24c*** designates an oil seal.

On the output shaft **21a** between the bearings ***24a*** and ***24b***, a guide groove ***26a*** (guide portion) for the intake valve is formed adjacent to a guide groove ***26b*** (guide portion) for the exhaust valve.

The guide grooves ***26a*** and ***26b*** have such a shape as "figure-eight" when developed (See FIG. **4**), folding around the output shaft ***21a*** portion of the overhung crankshaft **20** while returning back to the starting point in two turns. The roots of the guide grooves ***26a*** and ***26b*** are formed as cam faces, and higher portions ***27a*** and ***27b*** (FIG. **1**) are respectively formed at one location as to extend outwards in the radial direction of the output shaft ***21a***, and are circumferentially disposed so as to coincide with the crank angle respectively corresponding to each valve opening timing of the intake and exhaust valves.

A sliding piece **28** (an interlocking mechanism) for the intake valve is engaged with the guide groove ***26a***, and at the upper end thereof is provided with a sliding shaft portion ***29a*** formed into vertical slender rod shape as shown in FIG. **2**. The sliding shaft ***29a*** is rotatably and vertically slidably supported by a supporting wall **15***a* forming a part of the crankcase **14** in the engine block **10**. At the lower end of the sliding piece **28**, an arm **29***b* sideways extends essentially over the highest longitudinal line on the outer surface of the output shaft portion **21***a*, and can swing about the vertical axis of the sliding piece **28** as one-piece with the sliding piece **28**.

A ball **30** is rotatably pivoted on the tip end of the arm **29***b* extending sideways to engage with the guide groove **26***a*.

The upper end portion of the sliding shaft **29** projecting upwards of the supporting wall **15***a* provides a bulbous seat **29***c* on which is rotatably pivoted a bulbous lower end portion **33***a* of a push rod **32** disposed in a push-rod insertion hole **16***a*.

The upper end portion of the push rod **32** extends upwards of the cylinder **12** to push up one end of a rocker arm **34** from below. The rocker arm **34** is rotatably supported on the upper portion of the cylinder **12**, and the other end of the rocker arm **34** is depressed down against a valve rod **37***a* of an intake valve **36** to open it.

Another sliding piece **31** for the exhaust valve is similar to the above mentioned sliding piece **28** for the intake valve in construction. The higher portion **27***b* in the guide groove **26***b* on which the sliding piece **31** engages is disposed so as to coincide with the crank angle corresponding to the opening timing of aforesaid exhaust valve, i.e. so as to be located substantially 180 degrees apart from the other higher portion **27***a*.

At the upper portion of the sliding piece **31**, another push rod **38** similar in construction to the push rod **32** is also supported to open the exhaust valve (not shown in the figure) in the same way as the intake valve **36**. Numeral **40** in FIG. **1** designates a rocker cover.

Now, the following describes the operation. When the overhung crankshaft **20** turns, for example, the ball **30** for the intake valve **36**, being guided by the guide groove **26***a*, comes in sliding contact with the full length of circumference of the guide groove **26***a*, while the overhung crankshaft **20** makes two turns. During the two turns, the intake valve **36** is once pushed down open by the higher portion **27***a*. On the other hand, the arm **29***b* extending sideways swings to the left and right on FIG. **1** respectively by one degree while the overhung crankshaft **20** makes two turns, and the sliding shaft **29***a* portion of the sliding piece **28** also rotates, but the pivot bearing of the lower bulbous end surface **33***a* of the push rod **32** against the mating bulbous seat **29***c* ensures a smooth lifting action of the push rod **32** by the sliding piece **28**.

By the way, it is all the same with the push rod **38** for the exhaust valve.

Since the crank web **21***b* is required to contain only one overhung crankshaft **20**, the crankshaft **14** of the engine block **10** is constructed in small size, and also can be cut obliquely at the right lower portion thereof to be covered with the oil pan **10***a*.

Because the crankcase **14** incorporates the output shaft portion **21***a*, supporting at two locations with the bearings **24***a* and **24***b*, it can provide the output shaft **21***a* of the overhung crankshaft **20** with a proper support without eccentricity, which would release larger vibrations than with the normal-type crankshaft. Therefore, if the guide grooves **26***a* and **26***b* be formed on the output shaft **21***a*, the rotation axis of them will not fluctuate, which ensures an accurate lifting of the intake valve **36** and the exhaust valve caused by the sliding piece **28** and **31** through the push rods **32** and **38**.

Furthermore, a space, normally dead space in the prior art, surrounded with the side cover **16** over the crankcase **14**, can be effectively utilized by disposing the push rods **32** and **38** therein, which results in making the engine compact as a whole.

The following is the description of a second embodiment according to the invention, referring to FIG. **5**, in which the like reference numerals are provided for the like or corresponding parts as those in aforesaid first embodiment in FIG. **1**.

The second embodiment is adapted for a side valve type engine according to the invention, whose exhaust valve is not shown in the figure, but disposed behind and in juxtaposition to the intake valve **36** shown in FIG. **5**, perpendicularly to the paper.

A valve stem **37***a* of the intake valve **36** extends downwards while penetrating slidably through a supporting wall **15***a*. The lower end thereof depresses down against one of bell cranks **50** which constitute an interlocking mechanism **44** detailed later. It is all the same with the exhaust valve. The interlocking mechanism **44** provides a pair of the bell cranks **50** disposed symmetrically to each other with respect to the axis of the output shaft **21***a* and guided by a guide groove **48** (guide portion) to open the intake valve **36** and the exhaust valve. The guide groove **48** is formed on the output shaft **21***a* between a metal bearing **46** and a bearing **24***b*.

In this interlocking mechanism **44**, as shown in FIG. **6**, consisting of the bell cranks **50** and pivot shafts **52**, the bell cranks **50** fit onto the pivot shafts **52** disposed parallel to the output shaft **21***a* and to each other, so that the bell cranks **50** respectively can move axially and rock about the axis of the pivot shaft **52**. The tip ends of arms **51***a*, the lower portion of the bell cranks **50**, respectively engage into the guide groove **48** through balls **30**. And the tip ends of arms **51***b*, the sideways extending portion of the bell cranks **50**, are respectively in contact with the lower end of the valve stems **37***a* and **37***b* from below.

The guide groove **48** has such a shape, folding around the output shaft **21***a*, as to return back to the starting point in two turns, similar to aforesaid guide groove in FIG. **4**. And the root of the guide groove **48** is formed as cam face, and higher portions **49***a* (FIG. **5**) are formed so as to come into contact with the respective bell cranks **50** at the crank angles corresponding to the intake and exhaust valve timings.

In the engine shown in FIG. **5**, the respective bell cranks **50** rock about the pivot shafts **52** at the intake and exhaust valve timings by the cam action of the higher portions **49***a* so as to lift the intake and exhaust valve while the overhung crankshaft **20** makes two turns.

The following is the description of a third embodiment according to the invention, referring to FIG. **7**. In this embodiment, guide grooves **26***a* and **26***b* for driving the valves are not directly formed on the outer surface of an output shaft **21***a*, but on the outer surface of a collar **60** prefabricated on a block other than the output shaft **21***a* to fit thereto. Except for the above, the construction is similar to that of the first embodiment shown in FIG. **1**, so the like reference numerals are provided for the like parts as those in the first embodiment.

An inner surface 62 of the collar 60, substantially cylindrical, is in close contact with the outer surface of the output shaft 21*a*, and the collar 60 is secured in place on the output shaft 21*a* with pins 64.

Because, in the valve gear of this embodiment, as mentioned above, the guide grooves are formed on the collar 60 other than the crankshaft 20, the collar 60 alone can be precisely machined to form the guide grooves 26*a* and 26*b* on the outer surface thereof in the manufacture and assembly of the engine. In the machining operation of the guide grooves 26*a* and 26*b* having such a complex shape, the collar 60 can be easily set on the machine in any position or easily handled by the operator for machining, because the collar 60 is very small in size compared with the crankshaft 20.

To harden the guide grooves 26*a* and 26*b* prone to wear due to balls 30 pivoting thereto, only the collar 60 made separately from the crankshaft 20 is hardened and heat treated. Such being the case, the guide grooves 26*a* and 26*b* can be hardened, which results in reducing the wear of the guide grooves 26*a* and 26*b*, while the conventional guide grooves formed integrally with the crankshaft 20 has been difficult to be hardened.

In addition, if the guide grooves 26*a* and 26*b* get worn out after a long period of use, only the collar 60 ought to be taken out from the crankshaft 20 to replace with a new collar 60.

Adjusting the valve timing can be easily carried out only by changing the circumferential angle of the collar 66 to be placed and securing with the pins 64.

The following is the description of a fourth embodiment according to the invention, referring to FIG. 8 through FIG. 10. In the embodiment, the valve timing is made variable according to the running performance of the engine, by providing guide grooves 26*a* and 26*b* of the valve gear on a collar 60 made separately from an output shaft 21*a* so as to vary the timing angle of the output shaft 21*a*.

In FIG. 8 showing the major parts of the fourth embodiment, the like reference numerals are provided for the like or corresponding parts as those in aforesaid embodiment in FIG. 7.

The collar 60 is secured circumferentially to the output shaft 21*a* with set pins 70 so as to rotatably displace within a fixed degree as detailed later. A small space is provided between the right end surface of the collar 60 and the left end surface of a bearing 24*b*, in the figure, and a centrifugal governor 72 (timing adjusting mechanism) is provided therein for changing the valve timing.

As shown in FIG. 9, the centrifugal governor 72 consists of a governor weight 74, a coiled tension spring 76, a set pin 78 and an engaging pin 80. The governor weight 74 has such a shape as an arc extending over substantially half of the circumference of the collar 60, and set to a given mass. The lower end portion of the governor weight 74, in the figure, is rotatably fixed with the set pin 78 to a member 77 secured onto the surface of the output shaft 21*a* near the bearing 24*b*.

On the other hand, on the upper end portion of the governor weight 74, the engaging pin 80 is provided to engage with a cutout portion 82 (FIG. 8) in the collar 60, and also is engaged with the right end portion, in FIG. 9, of the coiled tension spring 76. The left end portion of the coiled tension spring 76 is fixed to the left end surface of the collar 60 (in FIG. 8) with a pin 84.

An arc-shaped groove 86 is formed on the inner surface of the collar 60 at the left end portion, and the collar 60 is rotatably held circumferentially onto the output shaft 21*a* within the arc-shaped groove 86 with aforesaid pin 70 engaging the arc-shaped groove 86.

From now, the operation of the fourth embodiment is described. When the engine starts running, the rotation of the output shaft 21*a* in the direction of Arrow A in FIGS. 9 and 10 produces a centrifugal force acting on the governor weight 74. At low speed with small centrifugal force, the governor weight 74 is being pulled to the left in FIG. 9 checked by the coiled tension spring 76, and the collar 60 connecting to the engaging pin 80 at the cutout portion 82 is poised at zero degree in advance angle when the higher portions 27*a* and 27*b* on the guide grooves 26*a* and 26*b* (cam face) line up almost vertically. Then, such valve timing as brought about can be desirable for low engine speed.

In time, as the engine speed comes up, as shown in FIG. 10, a large centrifugal force due to higher engine speed, acting on the governor weight 74 causes the upper end portion of the governor weight 74 to rotate about the set pin 78 in the right direction of the figure against the force of the coiled tension spring 76, thus causing the collar 60 connecting with the engaging pin 80 in the cutout portion 82 to rotation the direction of Arrow A. As the result, the higher portions 27*a* and 27*b* on the guide grooves 26*a* and 26*b* move within the arc-shaped groove 86, thus increasing the amount of advance angle by this amount of movement. Then, the valve timing will change into optimum setting for high engine speed.

As mentioned above, the invention can provide for:

a remarkable reduction in cost, and a compact size of engine, because of the elimination of the cam shaft;

elimination of the need for machining the speed-reduction gears and sprockets in use for the cam shaft, thus minimizing the time required for machining; and

a reduction of noise when the engine is running.

In addition, this invention is not limited to the above embodiments, but optimal combinations of the valve position and the interlocking mechanism can be selected at will.

The guide means is not limited to the guide grooves in the above embodiments, but the guide rails of metal bar can be alternatively employed.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is shown in the drawings and described in the specifications but only as indicated in the appended claims.

What is claimed is:

1. A valve gear adapted for use in a four-cycle engine comprising:

a crankcase;

a one-piece output shaft disposed within said crankcase;

a crankcase connected to said output shaft by a crankweb;

a first bearing supporting said output shaft at a first journal portion of said output shaft on said crankcase;

a second bearing supporting said output shaft at a second journal portion of said output shaft on said crankcase, said second bearing being spaced from said first bearing along the longitudinal axis of said output shaft to define a gap between said bearings and being larger than said first bearing, said second bearing being located adjacent to said crankweb;

two two-revolution guide grooves defined in said output shaft to be located within said gap, said guide grooves having roots forming cam faces and high portions;

the outer diameter of said second journal portion of said output shaft being larger than that of said output shaft portion on which said two two-revolution guide grooves are formed, and the outer diameter of said first journal portion of said output shaft being smaller than the latter; and

interlocking means movably engaged with said guide grooves and connected to valves associated with the engine to operate those valves according to the location of said interlocking means in said guide grooves.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,736,717

DATED : April 12, 1988

INVENTOR(S) : Tetsuzo Fujikawa, Toshiyuki Takada, Shinichi Tamba

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

column 6, line 57, "crankcase" should read -- crankshaft --

Signed and Sealed this

Twelfth Day of September, 1989

Attest:

DONALD J. QUIGG

Attesting Officer

Commissioner of Patents and Trademarks